

What is claimed is:

1. A monolithic ink-jet printhead, comprising:

a substrate having a lower ink chamber to be supplied with ink formed on an upper surface thereof, a manifold for supplying ink to the lower ink chamber formed on a bottom surface thereof, and an ink channel, which perpendicularly penetrates the substrate for providing communication between the lower ink chamber and the manifold;

a nozzle plate having a plurality of passivation layers stacked on the substrate and a metal layer stacked on the passivation layers, the nozzle plate having an upper ink chamber formed therein on a bottom surface of the metal layer, a nozzle in communication with the upper ink chamber formed on an upper surface of the metal layer, and a connection hole providing communication between the upper ink chamber and the lower ink chamber formed in and through the passivation layers;

a heater provided between adjacent passivation layers of the plurality of passivation layers, the heater being located between the upper ink chamber and the lower ink chamber for heating ink contained in the lower and upper ink chambers; and

a conductor provided between adjacent passivation layers of the plurality of passivation layers, the conductor being electrically connected to the heater to apply a current to the heater.

2. The printhead as claimed in claim 1, wherein the upper ink chamber has a diameter the same as or smaller than a diameter of the lower ink chamber.

3. The printhead as claimed in claim 1, wherein the connection hole is formed at a location corresponding to a center of the upper ink chamber.

4. The printhead as claimed in claim 1, wherein the connection hole may have a circular, oval or polygonal shape.

5. The printhead as claimed in claim 3, wherein the heater surrounds the connection hole.

6. The printhead as claimed in claim 1, wherein the connection hole comprises a plurality of connection holes formed adjacent an edge of the upper ink chamber.

7. The printhead as claimed in claim 6, wherein the heater has a rectangular shape.

8. The printhead as claimed in claim 6, wherein the plurality of connection holes are formed around the heater and spaced apart a predetermined distance from the heater.

9. The printhead as claimed in claim 6, wherein at least a portion of each of the plurality of connection holes is disposed within the boundary of the heater, and the heater defines a plurality of apertures, each of the plurality of apertures exposing one of the plurality of connection holes.

10. The printhead as claimed in claim 9, wherein each of the plurality of apertures is either a hole surrounding an entire one of the plurality of connection holes or a groove surrounding a portion of one of the plurality of connection holes.

11. The printhead as claimed in claim 6, wherein the lower ink chamber includes a plurality of hemispherical cavities in communication in a circumferential direction below a respective one of the plurality of connection holes.

12. The printhead as claimed in claim 11, wherein the ink channel is formed at a central portion of a bottom of each of the plurality of hemispherical cavities.

13. The printhead as claimed in claim 1, wherein the ink channel comprises a single ink channel formed at a location corresponding to a center of the lower ink chamber.

14. The printhead as claimed in claim 1, wherein the ink channel comprises a plurality of ink channels formed on a bottom surface of the lower ink chamber.

15. The printhead as claimed in claim 1, wherein the nozzle has a tapered shape in which a cross-sectional area decreases gradually toward an exit.

16. The printhead as claimed in claim 1, wherein the metal layer is made of one selected from the group consisting of nickel, copper and gold.

17. The printhead as claimed in claim 1, wherein the metal layer is formed by electroplating to a thickness of about 30-100 μm .

18. A method for manufacturing a monolithic ink-jet printhead, comprising:

(a) preparing a substrate;

(b) stacking a plurality of passivation layers on the substrate and forming a heater and a conductor connected to the heater between adjacent passivation layers of the plurality of passivation layers;

(c) forming a connection hole by etching to penetrate the plurality of passivation layers;

(d) forming a metal layer on the plurality of passivation layers and forming an upper ink chamber in communication with the connection hole on a bottom surface of the metal layer so as to be disposed above the heater, and forming a nozzle on an upper surface of the metal layer in communication with the upper ink chamber;

(e) forming a lower ink chamber in communication with the connection hole so as to be disposed under the heater by etching an upper surface of the substrate through the connection hole;

(f) forming a manifold for supplying ink by etching a bottom surface of the substrate; and

(g) forming an ink channel by etching the substrate between the manifold and the lower ink chamber to penetrate the substrate.

19. The method as claimed in claim 18, wherein the substrate is made of a silicon wafer.

20. The method as claimed in claim 18, wherein forming the heater and the conductor connected to the heater while sequentially stacking the plurality of passivation layers on the substrate comprises:

forming a first passivation layer on an upper surface of the substrate;

forming the heater by depositing a resistive heating material on an entire surface of the first passivation layer and patterning the same;

forming a second passivation layer on the first passivation layer and the heater;

forming a contact hole exposing a portion of the heater by partially etching the second passivation layer;

forming the conductor connected to the heater through the contact hole by depositing a metal having electrical conductivity on the second passivation layer and patterning the same; and

forming a third passivation layer on the second passivation layer and the conductor.

21. The method as claimed in claim 18, wherein the connection hole is formed by anisotropically dry-etching the plurality of passivation layers using reactive ion etching.

22. The method as claimed in claim 18, wherein forming the metal layer on the plurality of passivation layers and forming the upper ink chamber in communication with the connection hole on the bottom surface of the metal layer so as to be disposed above the heater, and forming the nozzle on the upper surface of the metal layer in communication with the upper ink chamber comprises:

forming a seed layer for electroplating on the passivation layers;

forming a sacrificial layer for forming the upper ink chamber and the nozzle on the seed layer;

forming the metal layer on the seed layer by electroplating; and

forming the upper ink chamber and the nozzle by removing the sacrificial layer and the seed layer formed under the sacrificial layer.

23. The method as claimed in claim 22, wherein the seed layer is formed by depositing at least one of copper, chromium, titanium, gold and nickel on the passivation layers.

24. The method as claimed in claim 22, wherein forming the sacrificial layer comprises:

coating photoresist on the seed layer to a predetermined thickness;

forming the sacrificial layer shaped of the nozzle by initially patterning an upper portion of the photoresist; and

forming the sacrificial layer shaped of the upper ink chamber under the nozzle-shaped sacrificial layer by subsequently patterning a lower portion of the photoresist.

25. The method as claimed in claim 22, wherein the initial patterning is performed on the nozzle-shaped sacrificial layer by a proximity exposure process for exposing the photoresist PR using a photomask which is separated from an upper surface of the photoresist by a predetermined distance, in a tapered shape in which a cross-sectional area of the sacrificial layer increases gradually downward.

26. The method as claimed in claim 25, wherein an inclination of the nozzle-shaped sacrificial layer is adjusted by varying a distance between the photomask and the photoresist and an exposure energy.

27. The method as claimed in claim 22, wherein the metal layer is made of a material selected from the group consisting of nickel, copper and gold.

28. The method as claimed in claim 22, further comprising:
planarizing an upper surface of the metal layer by chemical mechanical polishing, after forming the metal layer.

29. The method as claimed in claim 18, wherein forming the lower ink chamber comprises isotropically dry-etching the substrate exposed through the connection hole.

30. The method as claimed in claim 18, wherein forming the ink channel comprises anisotropically dry-etching the substrate from a bottom surface of the substrate having the manifold.

31. The method as claimed in claim 18, wherein the connection hole comprises a single connection hole formed at a location corresponding to a center of the upper ink chamber.

32. The method as claimed in claim 31, wherein the heater surrounds the connection hole.

33. The method as claimed in claim 31, wherein forming the ink channel comprises anisotropically dry-etching an upper surface of the substrate on a bottom of the lower ink chamber through the connection hole.

34. The method as claimed in claim 18, wherein the connection hole comprises a plurality of connection holes formed adjacent an edge of the ink chamber.

35. The method as claimed in claim 34, wherein the heater has a rectangular shape.

36. The method as claimed in claim 34, wherein the plurality of connection holes are formed around the heater and spaced apart a predetermined distance from the heater.

37. The method as claimed in claim 34, wherein the heater is patterned to define a plurality of apertures, each of the plurality of apertures

exposes one of the plurality of connection holes formed within or across the boundary of the heater.

38. The printhead as claimed in claim 37, wherein each of the plurality of apertures is either a hole surrounding an entire one of the plurality of connection holes or a groove surrounding a portion of one of the plurality of connection holes.

39. The method as claimed in claim 34, wherein forming the lower ink chamber comprises providing communication between a plurality of hemispherical cavities in a circumferential direction below the plurality of connection holes.

40. The method as claimed in claim 39, wherein the ink channel comprises a single ink channel formed at a central portion of the ink chamber and the plurality of hemispherical cavities are in communication in a radial direction due to the ink channel.

41. The method as claimed in claim 39, wherein the ink channel is formed at a central portion of a bottom of each of the plurality of hemispherical cavities.